Detection and Monitoring of Agricultural Drought for Famine Early Warning

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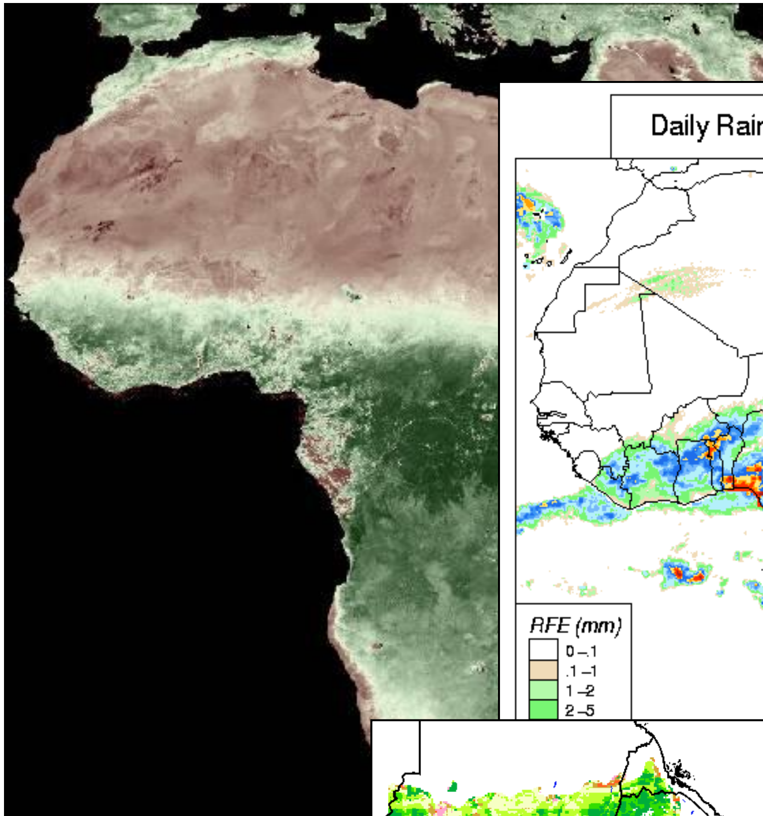
Agricultural Drought Monitoring

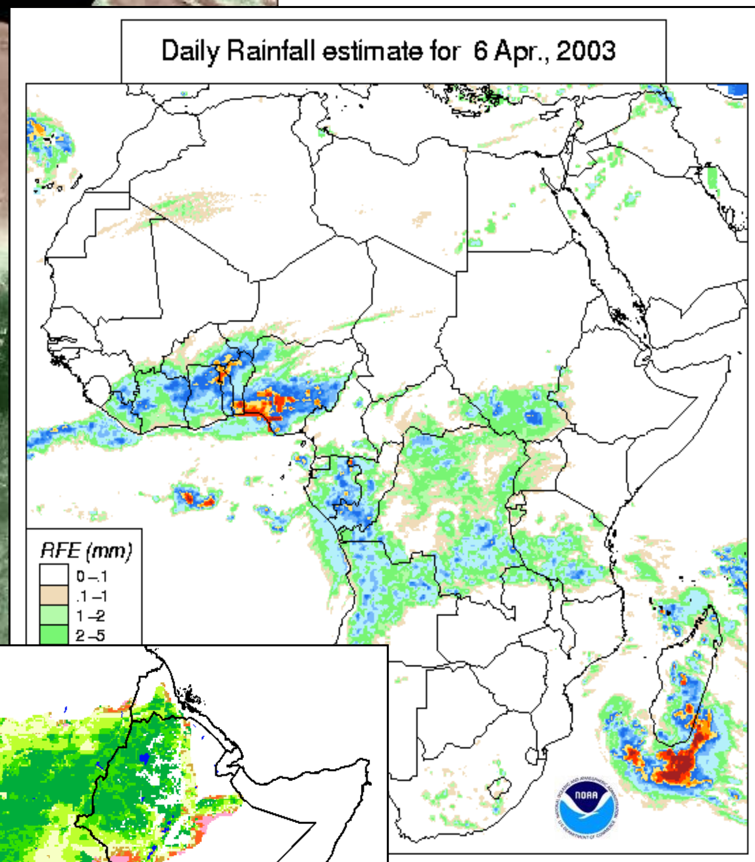
- Support to USAID Food for Peace
- Across Multiple Time Scales:
  - Current season….
  - Season ahead….
  - Climate change….

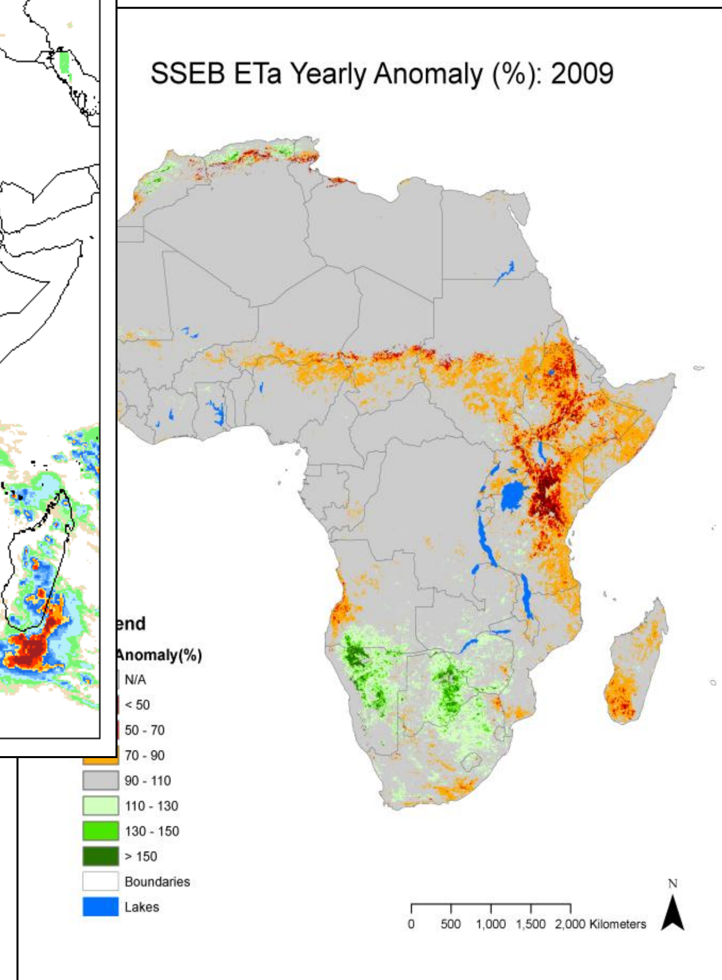
Agricultural Drought Monitoring

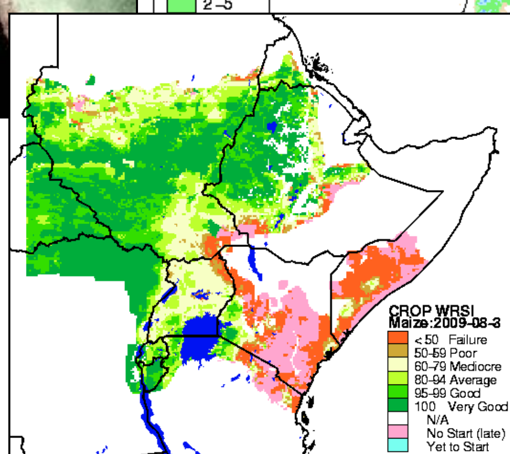
- Livelihood systems are based on subsistence agriculture and/or pastoralism, and are highly drought-sensitive
- Conventional climate station networks are sparse and/or late reporting
- Satellite remote sensing and models fill the gap, and provide the basis for early detection of agricultural drought

Agricultural Drought Monitoring







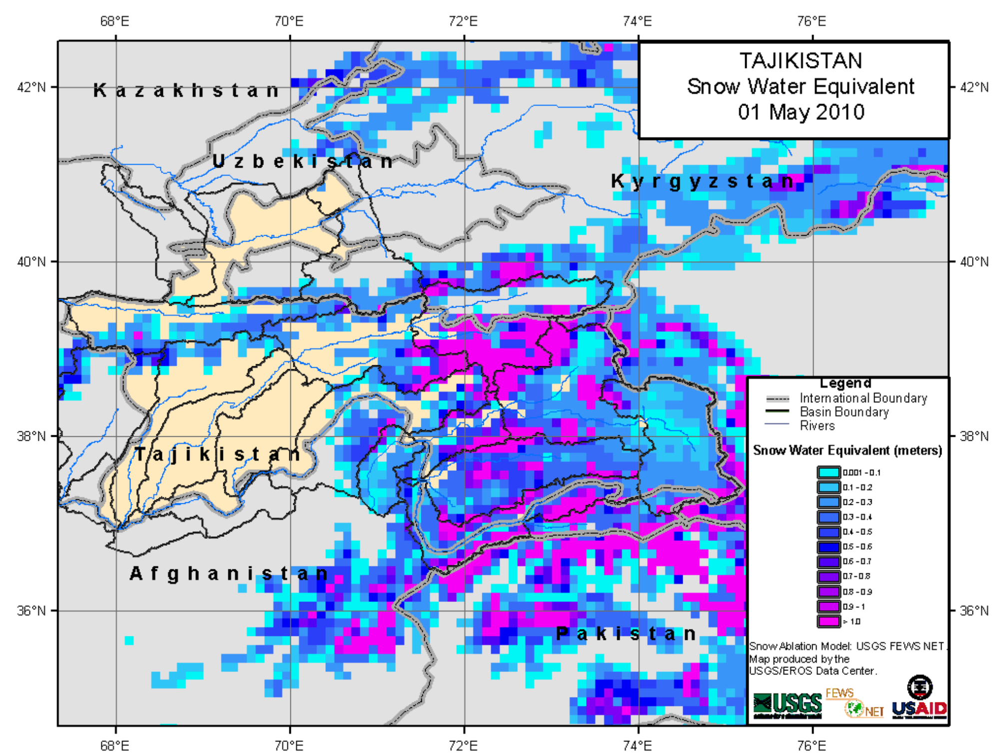


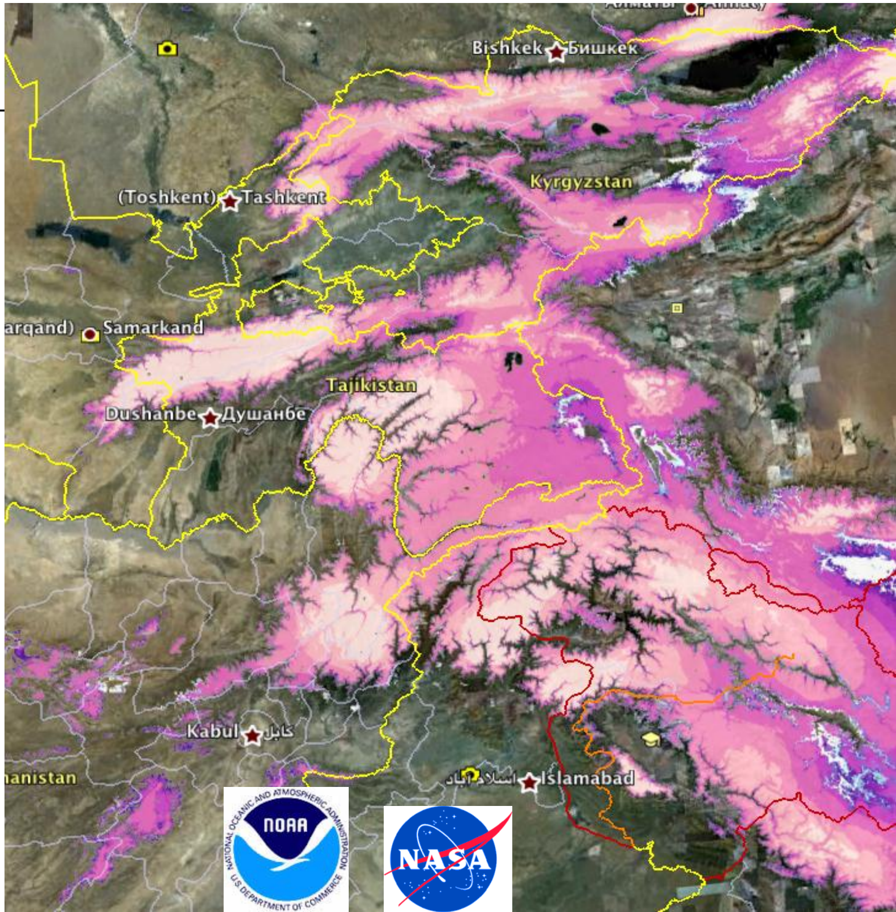
USGS
science for a changing world

Agricultural Drought Monitoring

Water from Snow Pack

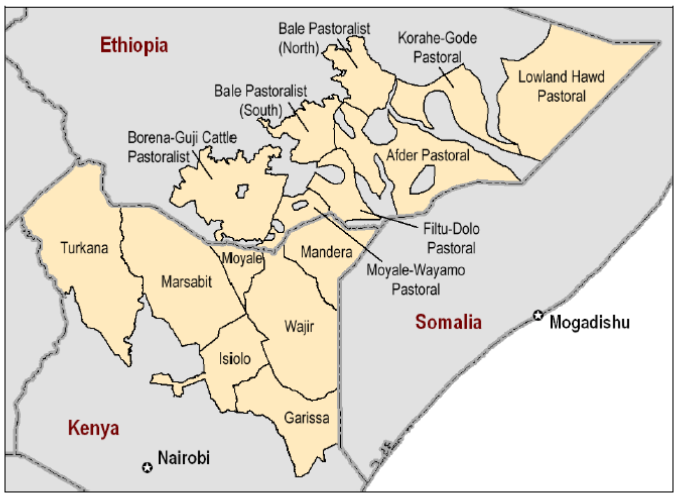
Models are needed to fill in spatially and provide homogeneous historical time-series





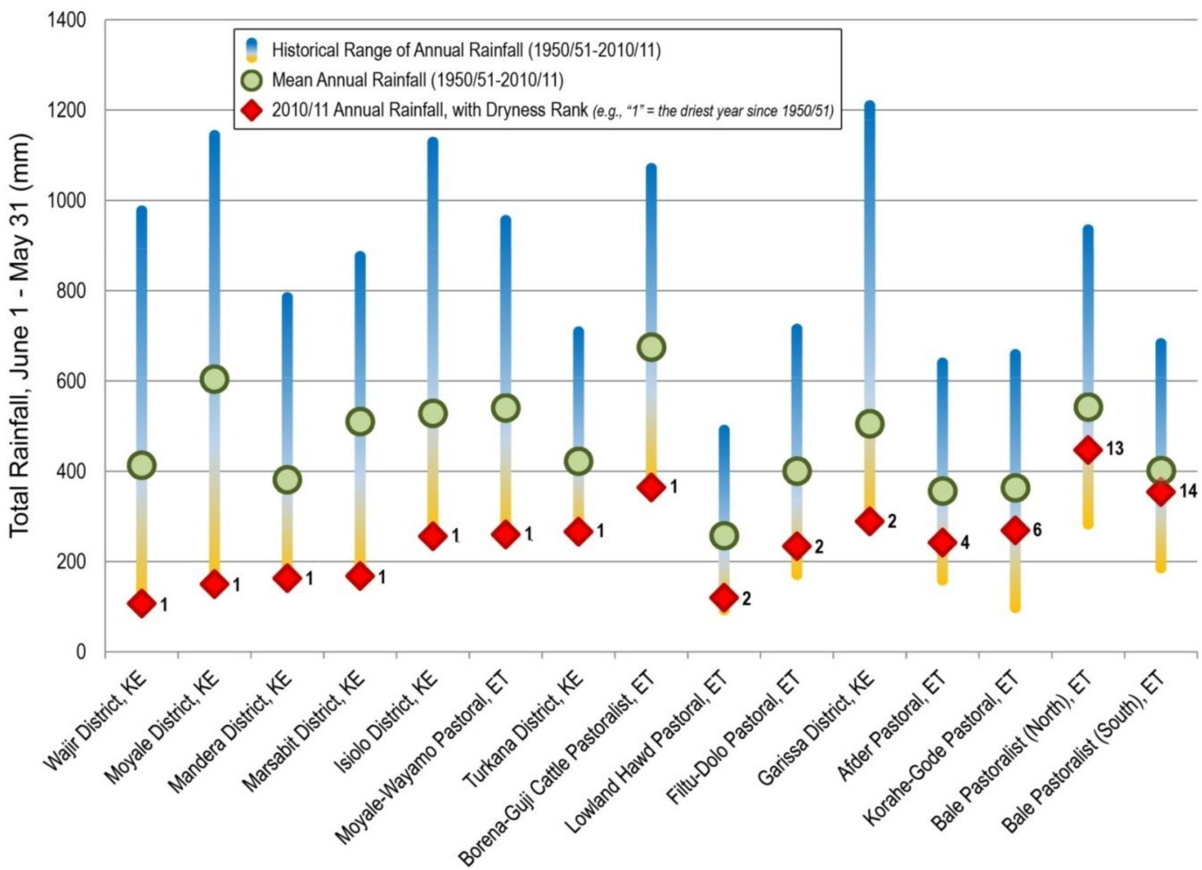
Declaration of Worst Drought in 60 Years

Figure 1. Selected drought-affected pastoral areas of northern Kenya and southern Ethiopia.



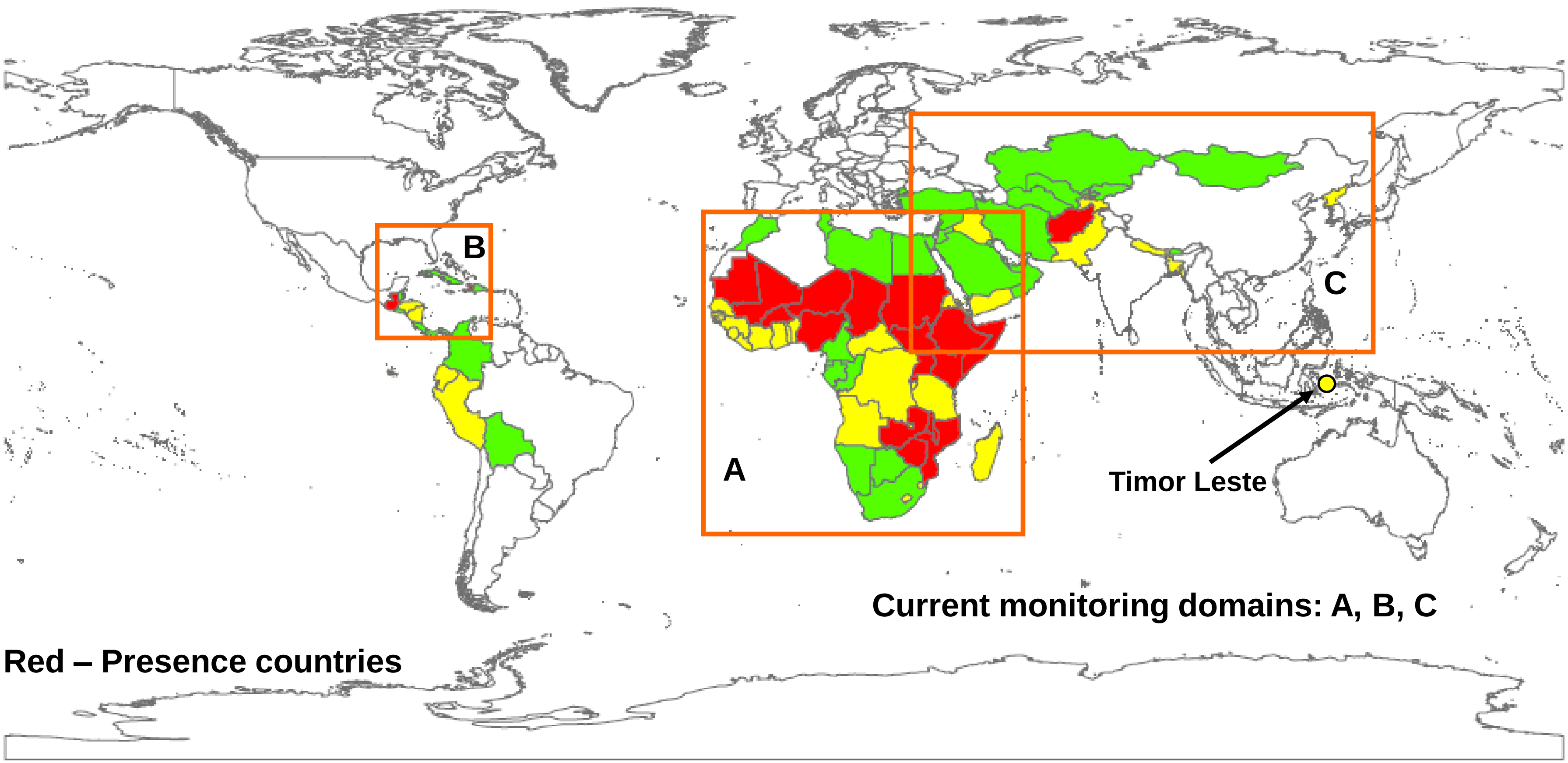
Chris Funk, USGS

2010/11 rainfall compared to historical totals since 1950/51 in select pastoral areas of Kenya and Ethiopia



Source: *FEWS NET*

FEWS NET Monitoring

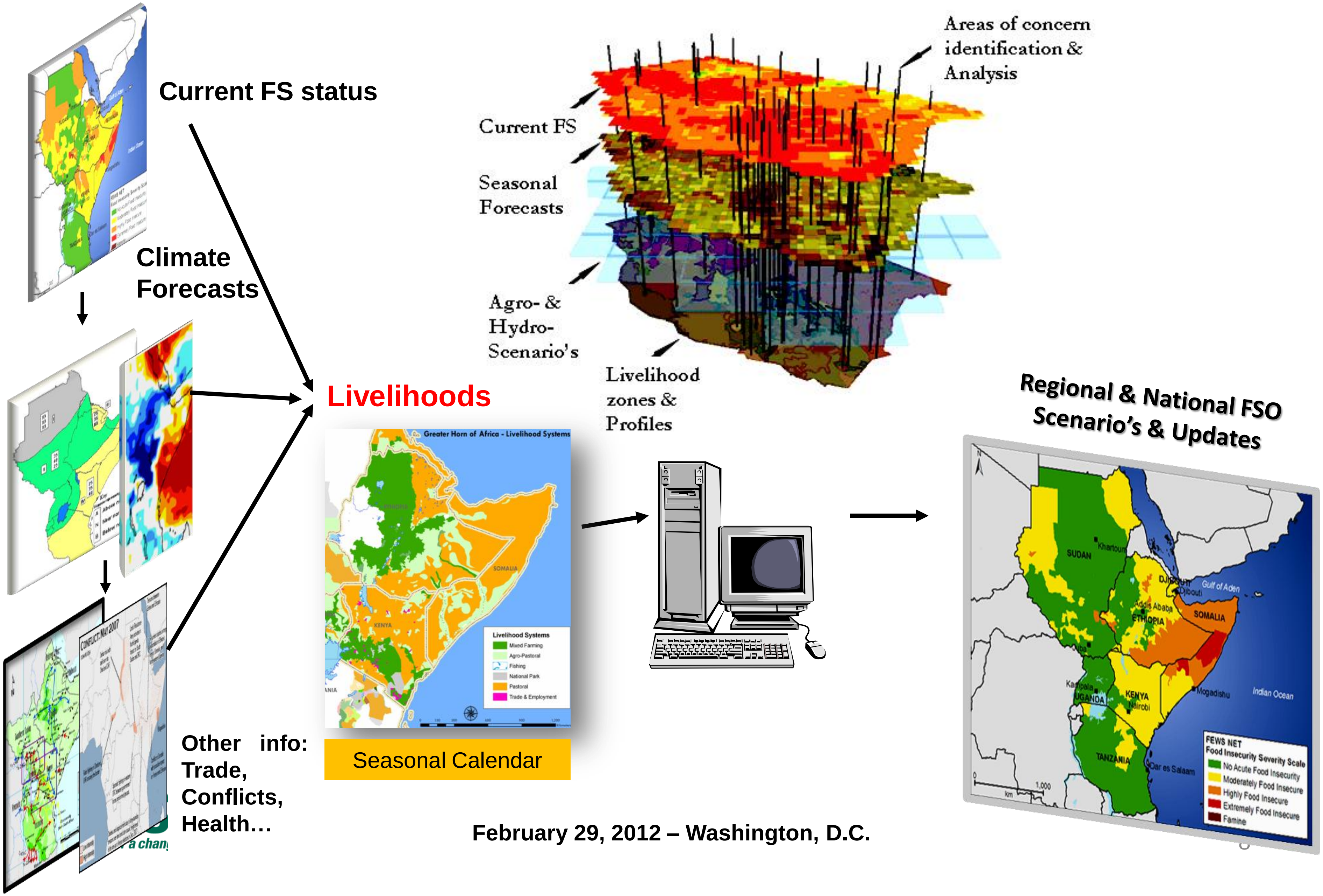


Red – Presence countries

Yellow – Remote agroclimatic AND availability/access monitoring

Green – Remote agroclimatic monitoring only

Food Security Outlooks



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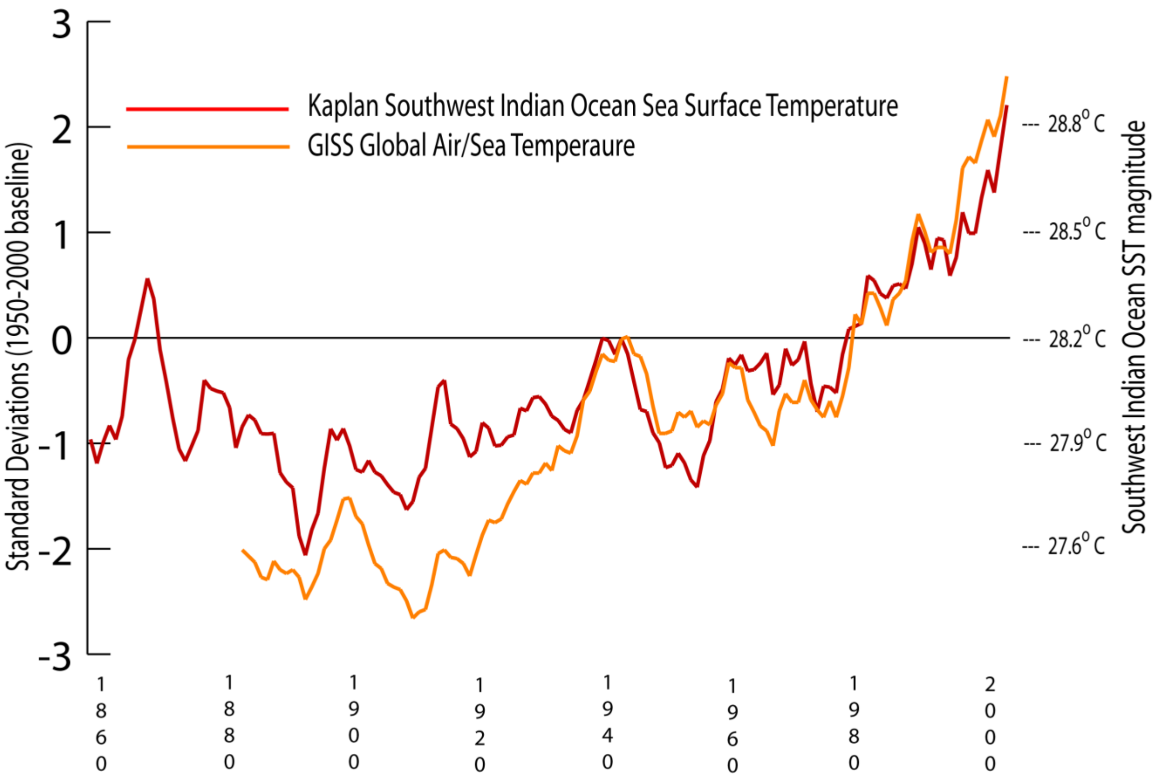
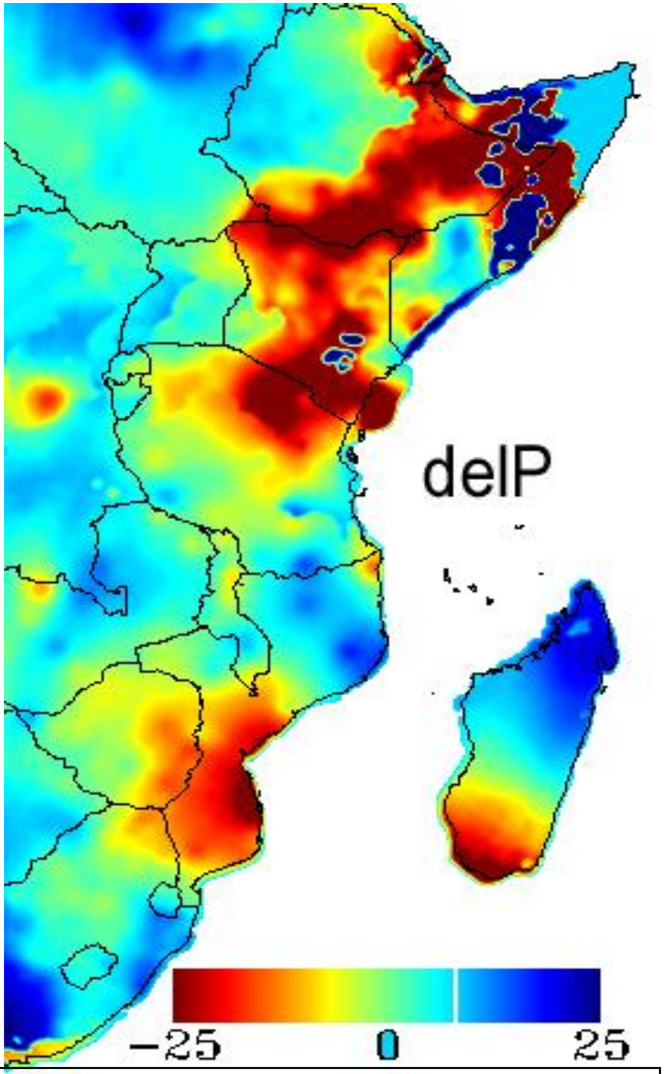


20th Century Global Surface Temperatures and Indian Ocean SSTs Rising in Tandem (Same "hockey-stick" rise since 1980)



Anticipated change in rainfall (as percent)
More agricultural drought lies ahead

Famine Early Warning Systems Network - Informing Climate Change Adaptation Series

A Climate Trend Analysis of Kenya—August 2010

Conclusions

- *Long rains in central Kenya have declined more than 100 millimeters since the mid-1970s. This decline is probably linked to warming in the Indian Ocean, and seems likely to continue.*
- *The observed drying tendency is the opposite predicted by the 4th Intergovernmental Panel on Climate Change (IPCC) assessment.*
- *A warming of more than 1° Celsius may exacerbate drying impacts, especially in lowland areas.*
- *The drying trends could particularly impact densely populated areas to the east, north, and north-west of Nairobi.*
- *Critical surplus crop growing areas in Central Kenya are threatened, and the amount of prime arable land could diminish substantially.*

Observed Drying Trends

This brief report draws from a multi-year effort by the United States Agency for International Development's Famine Early Warning System Network (FEWS NET) to monitor and map rainfall and temperature trends over the last 50 years (1960–2009) in Kenya. Observations from seventy rainfall gauges and seventeen air temperature stations were analyzed for the long rains period, corresponding to March through June (MAMJ). The data were quality controlled, converted into 1960–2009 trend estimates, and interpolated using a rigorous geo-statistical technique (kriging). Kriging produces standard error estimates, and these can be used to assess the relative spatial accuracy of the identified trends. Dividing the trends by the associated errors allows us to identify the relative certainty of our estimates (Funk and others, 2005; Verdin and others, 2005; Brown and Funk, 2008; Funk and Verdin, 2009). Assuming that the same observed trends persist, regardless of whether or not these changes are due to anthropogenic or natural cyclical causes, these results can be extended to 2025, providing critical, and heretofore missing information about the types and locations of adaptation efforts that may be required to improve food security.

The analyses clearly indicate cohesive patterns of observed climate change during the 1960–2009 era in rainfall (fig. 1) and temperature data (fig. 2). Extending the observed 1960–2009 changes out until 2025, we find that large parts of Kenya will have experienced more than a 100 millimeter (mm) decline in long-season rainfall by that date. Evaluations of independent rainfall data sets produce similar results (Williams and Funk, 2010). For Kenya, the relative magnitude of the identified long-season rainfall declines is generally more than three times the associated standard errors (table 1, supplemental map 1). These decreases in rainfall were accompanied by significant increases in average air temperatures, with the MAMJ temperature increases generally being more than twice the interpolation standard errors (table 1, supplemental map 2). This 1° Celsius warming value can be compared to the typical inter-annual standard deviation of MAMJ station temperatures, about 0.6° Celsius.

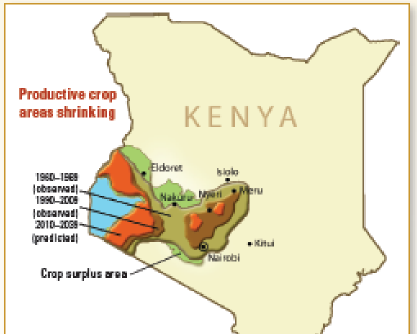


Figure 1. Climate change in Kenya: Average location of the 500 millimeter rainfall isohyets for the years 1975 (light brown), 1995 (dark brown), and 2025 (predicted, orange). The green polygon in the background shows the main crop surplus region of Kenya.

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Using Observed Warming to Identify Hazards to Mozambique Maize Production

Conclusions

- *Recent (2011) analysis indicates that 30 years of substantial warming has increased temperatures during the primary growing season in central Mozambique by ~1.5 degrees Celsius.*
- *The warming is affecting the maize crop's phenology by causing an onset of flowering 4 days earlier and a 5 to 7 percent decline in total time to plant maturation.*
- *Warmer temperatures earlier in the season threaten maize yields by exposing the plant at sensitive crop phases to increased heat and drought, and shortening the crop's growth cycle, thus reducing the size of the plant and the weight of its grains.*
- *Continued warming could increase the risk of these hazards and affect crop production, regardless of any changes in rainfall.*

New Perspectives on Crop Yield Constraints because of Climate Change

Climate change impact assessments usually focus on changes to precipitation because most global food production is from rainfed cropping systems; however, other aspects of climate change may affect crop growth and potential yields.

A recent (2011) study by the University of California, Santa Barbara (UCSB) Climate Hazards Group, determined that climate change may be affecting Mozambique's primary food crop in a usually overlooked, but potentially significant way (Harrison and others, 2011). The study focused on the direct relation between maize crop development and growing season temperature. It determined that warming during the past three decades in Mozambique may be causing more frequent crop stress and yield reductions in that country's maize crop, independent of any changes occurring in rainfall. This report summarizes the findings and conclusions of that study.

Assessing Changes in Temperature and Maize Development in Mozambique

The Harrison (2011) study analyzed historical changes in air temperature in Mozambique between 1979 and 2008, and collected data that relate the duration of specific maize plant growth phases to differing temperatures. Mozambique-specific planting dates were estimated using the U.S. Geological Survey (USGS) GeoWater Requirement Satisfaction Index (GeoWRSI.) The following changes in maize growth stages were assessed at nine locations (fig. 1):

- number of days from planting to flowering;
- duration of the reproductive period (flowering to maturity, days);
- total growth duration (planting to maturity, days);
- minimum, maximum, and average temperature during each of these periods, in degrees Celsius (°C); and
- 90th percentile maximum temperature during the reproductive period (°C).

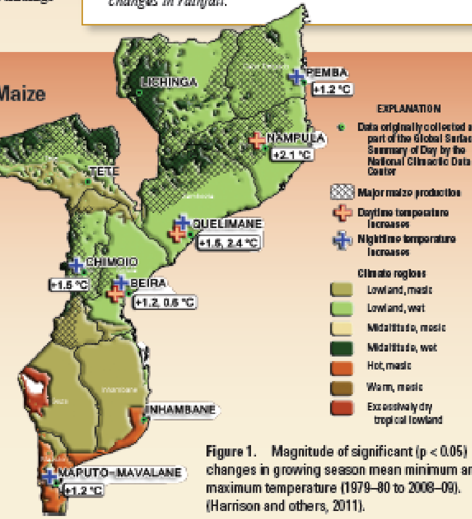

Figure 1. Magnitude of significant ($p < 0.05$) changes in growing season mean minimum and maximum temperature (1979–80 to 2008–09). (Harrison and others, 2011).

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Thank you